

Fig. 1.

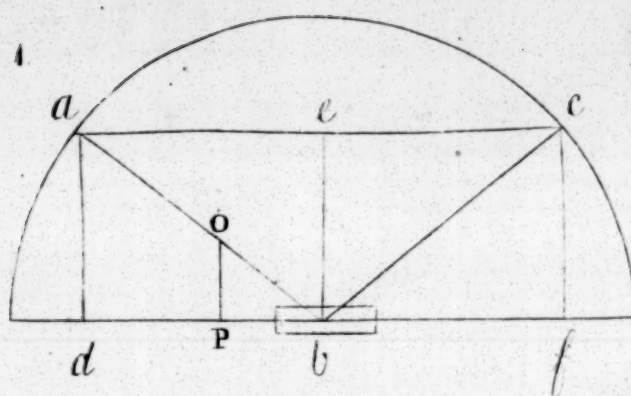


Fig. 2.

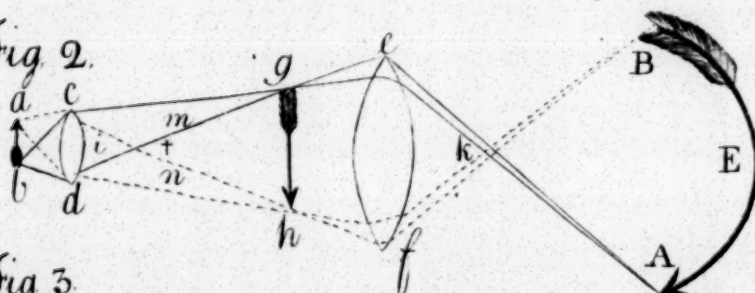


Fig. 3.

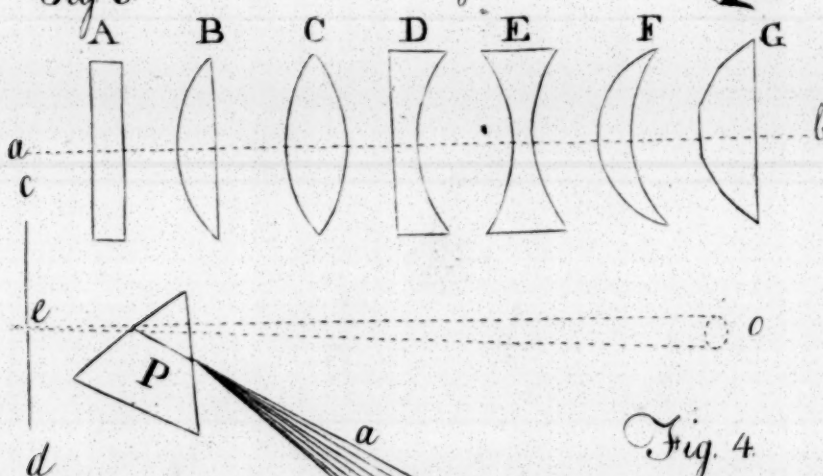
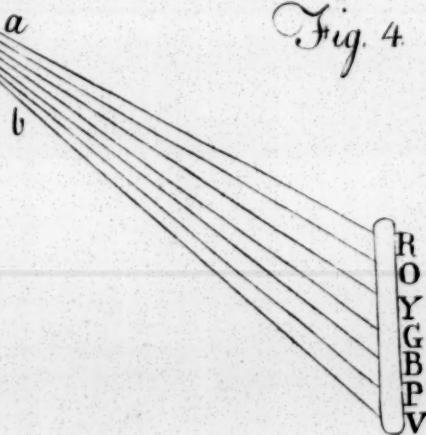


Fig. 4.



A
S K E T C H
O F
O P T I C K S :

DISPLAYING THE

Wonders of Sight and Manner of Vision :

The Cartesian and Newtonian Theories of Light :

Ideas of a newly created Man :

THE

Astonishing Appearances produced by plane Looking Glasses;
Concave and Convex Mirrours, and Multiplying Glasses :

*The different refrangibility of the Rays of Light, and the Nature of
Colours :*

The amazing burning Property of Lenticular Glasses, and
reflecting Mirrours :

*With a Description of the Mirrour, whereby Archimedes burnt the
Roman Fleet :*

A beautiful Aerial Scene described and accounted for :

The Construction of Microscopes :

Demonstrations of the Equality of the Angles of Incidence and
Reflection, by easy Experiments.

REMARKS ON MR. FINNY'S DEMONSTRATION, &c.

WHEREIN

Some Mistakes of his are corrected, particularly his Misconcep-
tion of *Doctor Berkley's* Definition of Tangible Objects
and their Representatives.

BY JOHN DONOVAN, P. M.

TOPOGRAPHER, PRACTICAL LAND-SURVEYOR & DIALLIST.

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A
S K E T C H
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P A R T I.

THE body of Light, conceived as an immense liquid, always furrounds us, but is not always pushed down to us. It is only constantly ready to serve and to inform us, at the very first shock it shall receive from the Sun, from a conflagration, a flambeau or a single spark. That fluid is, indeed, pushed by the Sun and by all inflamed bodies, but is neither the result or the effect of them. The Light then may have been created before the sun, and the Stars have been as it were immersed in it, in such particular situations, as to make them correspond by the communications of the motions they cause therein. Thus, all the spheres are involved in Light*: there they swim or roll according to the lines prescribed and appointed them. The Light renders them visible and useful to each other.

* Called by the Cartesians, MATERIA SUBTILIS. This theory of Light differs from the Newtonian, which denies light to be a fluid *PER SE*, but a vast number of exceeding small particles, flowing with an inconceivable velocity from ignited matter, either directly to the organs of sight, and then exciting the idea of light; or reflected from other objects, and then exciting the ideas of these objects in the mind. Both these theories have their advocates; both are *STILL* clogged with difficulties. I prefer the former, as according better with the Mosaic account.

It has been computed by Dr. Niewentyt, that six millions of millions of times as many particles of Light, flow from a single candle in a second of time, as there are grains of sand on the earth, though every solid inch thereof should contain one million. The velocity of Light is about 200,000 miles in a second of time.

It is remarkable of all fluids, first, that all the parts thereof are incoherent ; that they easily roll one over another, and are always ready to yield to the first impression. Secondly, that all these parts have either an inherent or borrowed activity, which causes them mutually to press each other every way, as if they were so many small circular springs, always inclined to dilate or fly out on all parts ; so that as much as one pushes the other, by so much it is reciprocally pushed thereby ; the force of each of which being equal, they counterbalance each other and remain all in a perfect equilibrio, if not agitated by some extraneous cause. But the fluid body of Light, struck by the enormous shocks of the Sun whirling on its own axis, receives from it such an agitation as reaches to the very spheres of the Stars.

The activity of that pressure, which has its source either in the Sun or some flaming body, is distributed into large waves, which are cut by all the points of every object that happens to cross their passage : but the pressures it has undergone, always lessen from one reflexion to another, by new subdivisions, and when, at last, it is restored to its state of equilibrium, it surrounds without striking us, and is nothing but darkness.

As Light is designed to enlighten the eye ; the structure of that noble organ is entirely disposed according to the nature of Light : it is divided into three partitions, filled with three different humours, and so disposed as to unite at the bottom of the eye the rays, which without that artifice would never arrive there in good order ; these three humours are called the Aqueous, the ChrySTALLINE, and the Vitreous : these humours are covered by three principal coats, *viz.* the Sclerotica, the Choroides, and the Retina.

The eye is a natural telescope, nearly of the form of a ball, somewhat longish in the forepart, and which the Creator has suspended by several muscles, to govern it according to our needs ; these, as well as all other muscles, shorten as they widen, and lengthen when they contract ; one is designed to raise the eye ; a second to lower it ; two others are appointed to bring it, by turns, towards the nose and temple, a fifth, which slides within a cartilaginous ring, like a cord over a pulley, and is fastened to the globe of the eye in two points, makes it roll about at pleasure ; a sixth lies under the eye, and is designed with comeliness, to temper and restrain within proper bounds the action of the rest, which might otherwise be excessive and shocking ; in short, there are a multitude of different pieces of mechanism which artfully assist each other, to make the eye advance forward ; retire, and move every way : the rays of Light flowing from all parts of every object presented to the eye ; the images of these objects will be painted on the back part of the Retina. The incident rays converging there to their
proper

proper foci, by the refraction caused by the different humours, and hence is the sensation of Light excited.

Let us now behold the wonders of that picture, which the rays delineate at the bottom of the eye; since it is that picture which becomes our proper Light; our guide, and our flambeau. What surprises me first herein, is, a perfect distinction and clearness, together with a most extraordinary littleness: for here is, nearly, one-half of the horizon distinctly painted within the compals of less than half an inch; hills, plains, rivers, buildings, trees, animals, &c. &c. The largest edifice in the kingdom, placed at a mean distance amidst this groupe, would be faithfully represented on the Retina, within the perimeter of less than the five hundred thousandth part of an inch: what a wonderful picture is this?

The Light reflected from a tree, and bent within my eyes, may affect them, 'tis true. But it delineates two † images in my eyes, and I see but one tree; it paints in my eyes an inverted † image, and I see the tree in a direct situation, and upright; it paints in my eye a tree, which does not, by much, fill the millionth part of one inch, and the tree I see is eighty feet high; I myself am not six foot high and two feet broad; and have the most real sensation, not only of a very large tree, but of nearly one-half the horizon, and of the distance which is between the Earth and the Sun; sure this is incomprehensible! But it is but the more evident that this marvel is the work, not indeed of the Light, which can only agitate the bottom of my eye; nor of nature, which is an idol; a mere ideal power, void of reality; but of God alone, who intimately operates within me; therefore the sight of the tree, and of the Sun, which God shews me, is as real and as immediate a revelation as that which led *Moses* to-

† To convince us of this, we have only to compare the parts of the room to which any object held near the face, is projected, on shutting one eye, and then by shutting the other; on opening both the eyes, the object will appear to retain a place between both these extremes. The experience of those who are born blind, and who afterwards recover their sight, confirms beyond a doubt, that we see every object double. The sense of feeling corrects this error of sight.

‡ Should you doubt of the inversion of the image in your eye, you might convince yourself of it by placing at the hole of a window shutter, which looks towards any publick place, the eye of an Ox, fresh killed, after having curiously taken off the thick envelopements which surround the bottom of the eye, even to the transparent pellicle which incloses the last humour; it is fit you should apply an oiled paper to it, then the objects outside will be seen painted most clearly, and in a wonderful foreshortening on the oiled paper; but all the images will be inverted.

We should consider that INVERTED is only a relative Term, and that there is a very great difference between the real object and the means, or image by which we perceive it. When all the parts of a distant prospect are painted on the Retina, they are all right with respect to one another, as well as the parts of the prospect itself; and we can only judge of an object, being inverted, when it is turned reverse to its natural position, with respect to other objects which we see and compare it with.

wards

wards the burning bush. The only difference between both these actions of God, on Moses and me, is, that the first is out of the common order and economy ; whereas, the other is occasioned by the sequel and connexion of the motions God has established, to rule both man and nature. The habit of seeing so soon as we open our eyelids, makes us look upon that operation as a thing extremely plain and intelligible ; however, I shall boldly answer, that the mysteries of our holy religion are not more above our understanding, than the manner in which we see, or than that inmost sentiment, which we experience of the disposition and magnitude of the things which are so remote from us. That my eye, by the help of an image, about half an inch broad ; or my soul, with an organ of half an inch, should see eight or ten square leagues, and discern the beauty ; the form, the situation, and distances of one million of objects, dispersed all over a plain, is a mystery truly inaccessible to all our reasonings. That operation must either be corporeal or spiritual ; but whatever it may be supposed to be, it will in both cases be equally above our reason ; it is an unfathomable abyss ; but it is a truth, and an undoubted matter of fact. What I can conceive of it, (and that is a great deal for me) is, first, that God being alone able to work this marvel within me, I continually experience the effect of his presence and goodness : secondly, that in nature, as well as in religion, he is pleased to grant me the use and communication of certain blessings, and of certain truths, without unveiling to me, as yet, the ground and nature of what he vouchsafes to inform me of ; and in short, that to dispute proved and duly attested truths, by alledging that one does not conceive them, is as little reasonable, as if I should say, I actually do not see these numerous objects about me, because I do not conceive how, being so little, I could have the perception of so vast an extent. *Unbelievers* build on the authority of this principle of modern philosophy : viz. not to admit of any thing, but what we clearly and evidently know. Let them say then, when they open their eyes to the Light, *I see nothing ; for I conceive not how any one can see.*

If (with Mr. Buffon) we imagine a man newly brought into existence, the following description would correspond with his ideas on the illusions of sight. “ I opened my eyes ; the Light of the day ; the azure vault of Heaven ; the verdure of the Earth ; the chrystal of the waters, all employed me at once, and animated and filled me with inexpressible delight. Impressed with this, I turned my eyes towards the Sun ; its splendor dazzled and overpowered me ; I turned my eyes upon a thousand various objects, and soon found that by opening and shutting them, I could lose and restore them at will. Agitated, *roused* by the pleasure

pleasure of this delightful sensation, I instantly arose; I had scarcely proceeded forward, when the novelty of my situation, once more, rendered me immoveable. My surprise returned; I supposed that every object around me had been in motion; I gave to them that agitation, which I produced by changing place; and the whole creation seemed to me in disorder. Upon casting my eyes upon my body, and surveying my own form, I thought it greater than all the objects that surrounded me; I examined the formation of my hand, and all its motions; it seemed to me large, or little, in proportion as I carried it to my eyes; I began soon, however, to find that my sight gave me uncertain information, and resolved to depend on my feeling for redress. I now, therefore, resolved to touch whatever I saw; and vainly attempted to touch the Sun; at every effort I fell from one surprise into another, for every object appeared double, and equally near me; and it was not till after an infinity of tryals, that I found some objects farther removed than the rest."

END OF PART THE FIRST.

P A R T II.

A DESIRE of bringing the important services of Light to perfection, has caused men carefully to study the reflections and refractions of it. They have explored all the paths, and the most delicate variations of it, and found out, either in the boundings or bendings of the Light, Rules so constant and steady, that they have been made a most certain science, and an art productive of a thousand useful contrivances. To this study we are beholden for the making and cutting of looking-glasses, of jewels, of glasses cut facet or tablewise, concave, relieve, &c. of reflecting and refracting telescopes, microscopes, and of an amazing multitude of other instruments fit to assist Astronomers and the common use of sight. There are two laws which light invariably follows, which are the foundation of the most curious things that can be said about it, and of which we may, in a great measure, be informed by the bare testimony of our senses. The one belongs to reflection the other to refraction.

* The

The rule of Reflection consists in knowing, that the light falling perpendicularly towards the surface of a new medium, returns from it again in a perpendicular line ; but that, when it falls towards it obliquely, it bounds back from it on the contrary side with the like obliquity : or, what is the same thing, that the angle of incidence is equal to the angle of reflection.

The rule of Refraction consists in knowing, first, that the light which enters a medium perpendicularly, suffers no bending there, and is impelled onward according to the same direction. Secondly, that when its path is in an oblique direction from a rarer medium, into a denser, it deviates from this obliquity, in its course through the body of the medium, and inclines towards the perpendicular. Thirdly, that when its path is from a grosser or denser medium, into one that is less compact or more rare, as out of glass or water into air ; it deviates from the perpendicular, and inclines to the surface of the lighter medium.

The reflection of light from the surfaces of mirrors, constitutes the subject of Catoptricks, and from the following principle, viz. Light reflected from any mirror or speculum, makes the angle of incidence equal to the angle of reflection ; we account for the following astonishing appearances, produced by looking-glasses and mirrors of various kinds. In a PLANE MIRROR or looking glass, the images are perfectly similar and equal to the objects they represent, and appear as far behind the glass as the objects are before it ; things on the right hand appear on the left, and the contrary. The whole body may be seen in a mirror, the length and breadth of which, is half the body's length and breadth. If the mirror be inclined in an angle of 45 degrees, an object perpendicular to it will appear parallel ; and an horizontal object, perpendicular ; hence a globe, descending down a plane, a little inclined, may, by means of a looking-glass, appear to be mounting a vertical plane, as if from the floor to the ceiling. If you move towards a large mirror, inclined as above, and keep the eye from the feet, you will appear as if flying horizontally. If a mirror be fixed horizontally to the ceiling of a room, objects on the floor will appear above the ceiling, and people on their feet, as if on their heads. In looking-glasses (from their double reflection in determinate positions of the eye and object, several images of the same object may be seen ; but in opaque mirrors, only one object can be seen. If two plane mirrors meet at an angle of 120 degrees, the eye placed in that angle, will see the image of an object placed therein, represented twice ; if at an angle of 72 degrees, five times ; if at an angle of 30 degrees, eleven times ; &c. If the mirrors be inclined at an angle somewhat greater than a right one, and that you then retire from, or approach to them, till the images coalesce, the face will appear with

with only one eye ; if the angle be less than a right one, you will see three eyes, two noses, two mouths, &c. ; at an angle still less, you will see two heads ; at an angle somewhat greater than a right one, and at the distance of four feet, the body will appear without a head ; if the mirrors decline from each other, the images will appear still more romantick.

In a *spherical convex mirror*, the image is less than the object ; for this reason convex mirrors are of great utility in the art of painting, when objects are to be represented less than the life : the more remote the object, the less the image. Objects perpendicular to the mirror appear topsy turvy. The image of a right line perpendicular to the mirror, is a right line ; the image of a right line parallel or oblique thereto, is convex or bent outwards. The effects of Light when reflected from a convex mirror, are weaker, or diverge more, than when reflected from a plane mirror : hence it is that Myopes or short sighted people see things more distinctly in a convex mirror, than they do directly.

Spherically concave mirrors. The image of an object receding continually from the mirror, is erect, and increases in magnitude till it comes to the center, where it appears confused ; if within these limits the object be moved to the right, the image will move to the left ; if the object be elevated, the image will be depressed, and the contrary. If the eye and object be placed in determinate positions beyond the center, the object will appear double and inverted, if the eye and object recede still farther beyond the center, the two images will appear to coalesce, and become one, and will appear projected in the open air, between the eye and glass ; hence if a man flourish a sword before a large mirror, another appears to come out thereof, to meet him, with the same motions ; and if he stretch out his hand, another hand will appear to be stretched out of the mirror, to meet it in the open air. The image of a right line perpendicular to a concave mirror, is, a right line ; but the images of oblique and parallel lines are concave, or bent inwards. If the flame of a candle be placed in the focus of the mirror, an intense light will be projected to an immense distance ; so far that a person may read four or five hundred feet from the candle, without the aid of any other Light. If the Light of a fire be reflected from a large concave mirror to its focus, on a smooth mahogany table, placed at a considerable distance from the fire, in a large darkened room, a person coming into the room, not acquainted with the experiment, and standing near the fire, will imagine he sees the table in a blaze, and that the house is in danger of being set on fire. If a lighted candle be substituted for the fire, the appearance of a fine large Planet, as bright as Venus, will be seen on the table, and if a candle, whose flame is

much less, be moved round the former, you will have the appearance of a beautiful satellite to the Planet.

Every spherically concave mirror collects the rays after reflection, into a point called the focus, or rather into a small compass; the section of which is a circle; hence arrives the surprising burning quality of these mirrors. Antient historians relate that Proclus and Archimedes* were furnished with mirrors; by which the fleets under Vitalian, besieging Byzantium, and that under Marcellus, besieging Syracuse, were burnt to ashes. Vilette, a Frenchman, constructed one capable of melting a silver six-pence in seven seconds, and a King George's half-penny in sixteen. Buffon has constructed some of far more surprising effects.

Refraction. Glass is ground into various shapes for dioptrical purposes; the principal of which are, a *plano glass*; a *plano convex*; a *double convex*; a *plano concave*; a *double concave*; a *meniscus*; a *flat plano convex*, and a *prism*; represented under the letters A, B, C, D, E, F, G. fig. 3, and P, fig. 4. The figures B, C, D, E, F, are called lenses, and the line *ab*, passing perpendicularly through the middle, is called the axis; the curved surfaces of the lenses are spherical: on the due adjustment of lenses depends the construction of Microscopes, Telescopes, and many other optical instruments.

The single refracting *Microscope* (fig. 2) is only a small convex glass *cd*; having the object *ab* placed in its focus, and the eye placed at the same distance on the other side; so that the rays of each pencil, flowing from every point of the object on the side next the glass, may proceed parallel in the space between the eye and the glass, and thereby entering the eye at *i*, they will be converged into as many points on the Retina, and there form the large inverted picture, *gh*.

The double refracting *Microscope* (fig. 2) consists of an object glass *cd*, and an eye glass *ef*; the small object, *ab*, is placed at a little greater distance from the glass *cd*, than its principal focus, so that the pencils of rays may be made to converge between *g* and *h*; where the image of the object will be formed, which image is viewed by the eye, through the eye glass *ef*; the rays then entering the eye at *k*, will begin to converge by the refractive power of the humours, and will form the large inverted picture, A. E. B. on the Retina. If the image, *gh*, be six times the distance of the object *ab*, from the object glass *cd*, and viewed by an eye glass *ef*, of one inch focus, the

* The mirror whereby Archimedes is reported to have burnt the Roman fleet, consisted of a number of square glass mirrors, silvered over, held together by a frame; each of these mirrors was also moveable at pleasure, so that all their reflections may occasionally unite; the distance of the focus, when the whole was duly adjusted, has been reckoned about 40 yards.

picture A. E. B. will be one thousand two hundred and ninety-six times greater than the object *a b*.

The solar Microscope is a tube containing two convex glasses, *ef* and *cd*, fig. 2, and the transparent object to be magnified, placed between them; one end (*ef*) of the tube is then to be fixed in a round aperture, made in the window shutter of a darkened room, so as to receive the solar rays directly, or by reflection from a plane looking-glass; a large inverted picture of the object will then be seen on white paper, placed behind the tube to receive it. On the same principle is constructed the magick lanthorn.

The *double convex*; *plano convex*, and *concave convex* lenses, collect the Sun's rays into a focus, and, therefore, become burning glasses. Mr. Parker, an Englishman, has constructed a burning lens, which has been known to melt ten grains of platina in three seconds, and twenty grains of pure gold in four seconds.

The flat plano convex, or multiplying glass; an object seen through this glass will appear multiplied into as many † different objects, as the glass contains plane surfaces.

The prism. The use of the prism is to separate the different rays of Light in passing through it.

By the following curious experiment we prove the different refrangibility of the rays of Light, by which the ideas of their different colours are excited in our minds: into a darkened room, let the Sun shine through a small hole in a window shutter at *e*, fig. 4; then place a triangular prism *P*, so as to receive the rays obliquely on one of its sides; the rays in passing through the prism, will be refracted according to their different natures, and if a sheet of white paper be so disposed, as to receive the rays after refraction, a series of the most beautiful colours will be seen painted thereon, and not to be equalled by the utmost effort of

† The following is a faint description of one of the most beautiful and extraordinary optical illusions that ever the eye beheld, and which I once had the pleasure of seeing myself. On the southern coast of Italy, near the ancient city of Rhegium, in the summer season, a spectator is frequently delighted with the appearance of a spacious and grand amphitheatre, in the air, over the Tyrrhenian Sea: a variety of indescribable scenes; the images of castles, palaces, and other buildings of the finest architecture, ranges of pillars, &c. all represented according to the most accurate rules of perspective. Upon the passing by of a cloud, this wonderful scene is changed and another immediately succeeds: then may you behold a most beautiful landscape; spacious woods, groves of cyprus, orchards with a variety of trees: meadows with vast companies of men and women, and herds of beasts, walking, standing, lying, &c. and all painted with such an admirable commixture of light and shade, that it is impossible to form an adequate conception of the picture without seeing it. The cause of this astonishing phenomenon, is this: the strand, and bottom of the sea along the Sicilian coast is covered with pellucid concretions, by the intense fervour of the Sun, the smallest particles of these are raised with the vapour, and coalesce into a cloud, which partakes of the nature of a multangular or multiplying looking glass; the various superficies of the resplendent granules cause the multiplication of the same object, and one pillar on the shore is multiplied almost to infinity.

art: towards one extremity of this figure or spectrum, you perceive the finest intense red; next the orange; then the yellow; the green; the blue; the purple, and the violet, in the order represented by the initial letters in the figure. These seven colours are called primary colours, and if they be united, which may be done by placing a double convex lens C, fig. 3, in the rays at $a b$, and then fixing the paper in its focus; then will the reunion of the rays form the clearest and most lively white; white, therefore, is a composition of all colours. If the paper be placed beyond the focus, then the order of the colours will be inverted, *viz.* the violet will appear above and the red below. From the combination of the primary colours, and of their several degrees variously blended, the brown; the olive, and all the subordinate colours do proceed. Black is not in nature, and is only a privation of reflected Light.

Of the equality of the Angles of Incidence and Reflection.

Proposition. If a ray of Light fall on a plane reflecting surface, or speculum of any form, it will be so reflected that the angles of incidence and reflection will be equal. The geometrical demonstration of this proposition, is deduced from the nature of perfectly elastick bodies, and the resolution and composition of * motion, thus, fig. 1: let the incident ray be expounded by $c b$; $c e$ will expound the parallel motion, and $c f$ the perpendicular one; the perpendicular motion, after reflection, will be equal to that before reflection, and, therefore, will be expounded by $b e$, equal $c f$; the parallel motion being unaffected by reflection continues uniform, and therefore, will be expounded by $b d$, equal $c e$; therefore, the course of the reflected ray will be $b a$: complete the equal and similar rectangles $e f$ and $e d$, and by the fourth of book the first, Euclid's Elements, the angles of incidence and reflection $c b f$ and $a b d$; or $e b c$ and $e b a$ are equal. For a curious analysis of this proposition, see Keill's *Vera Physica*.

Demonstration of the same Proposition by new Experiments.

PLACE a looking glass, or any plane mirror at b , on the horizontal plane $d f$; at f and d , in the same right line with the middle of the mirror, and equidistant from it, erect the perpendicular objects $f c$ and $d a$, equal in height; if the eye of

§ By the focus of this lens, is meant, the center of the sphere of the glass's convexity.

* The progressive motion of light was first proved by Professor Romer, from observations which he made on the eclipses of the satellites of Jupiter. The corporeity of light has been confirmed by experiments made by Mr. Michell and Mr. Morgan. See Philosophical Transactions, Vol. 75

the observator be then placed at a , the image of the point c will be seen on the middle of the mirror: hence, from the equality of the sides and contained angles, the angles of incidence and reflection, cbf and abd , will be equal; and because the reflection of the point c , will appear on the same part of the mirror to the eye, placed any where in the line ba , or in that direction, but no where else; it is not necessary that bf and fc should be, respectively, equal to bd and da , but that they bear the same ratio to each other; for in that case the triangles will be similar. As water partakes of the earth's rotundity, a basin of water will answer the purpose of a looking glass.

Experiment 2. Let the four sided figure at b , represent a plane looking-glass, placed vertically over the horizontal floor $adcf$; describe on the floor the equal angles cbf and abd , concurring at a point immediately under the middle of the glass, as represented fig. 1, place a lighted candle, or any other object, over any part of the line bc , elevated above the floor; suppose as high as the middle of the glass, or the eye of the observator; then will the eye, placed any where in the direction ba , and elevated as above, see the object by reflection at b ; but if the eye be placed out of that direction, the point of reflection will also change its position.

By these two experiments, altitudes, heights and distances may be determined. thus, suppose the Sun, Moon or Star at s , reflected to the eye at o , by the reflecting substance b ; then will Radius be to the tangent of the Sun's, Moon's or Star's altitude, as bp to po . Again, suppose fc a tower or tree, the top of which is reflected to the eye at o ; say, as bp to po , so bf to fc , the height required. In like manner inaccessible distances may be calculated; observing this difference, that in the former case the reflecting substance is to be placed horizontally; in this vertically.

END OF PART THE SECOND.

AS MR. FINNY and I differ in our definitions of the angles of incidence and reflection, our demonstrations of their equality, &c. I shall here take the liberty of transcribing his letter, &c. on this curious subject, and of making such remarks, as, I flatter myself, will appear to the reader, consistent with the most candid criticism.

TO THE EDITOR OF THE CORK GAZETTE.

S I R,

IF you think the following Demonstration *sufficiently genuine to prove*, the Angles of Incidence and Reflection equal
geometri-

geometrically, as required by the querist of this *Catoptric* Theorem, some time since in your paper, and received no other investigation to answer the proposer's intention, your inserting them will oblige

Your humble servant,

WILLIAM FINNY.

Demonstration. According to the great German philosopher, Leibnitz, a ray of light goes the shortest direction possible; *this granted.*

Let ab fig. 1. be the incident ray, b the point of incidence in the reflecting surface; bc the reflected ray, now the sum of the trajectories, ab and bc being a minimum, the angles abd , and cbf , will be equal, as proved in Stone's Euclid and Simpson's Geometry*, consequently their complements, abe and ebc , the angles of incidence and reflection are equal. Eb , being perpendicular to the plane df , erected from the incident point. Ab and bc , the representatives of the tangible trajectories, and the whole a representative of a tangible diagram, as demonstrated by Bishop Berkely, in his philosophy.

This appears to me a very extraordinary kind of demonstration, it amounts precisely to this: according to Simpson's Geometry and Stone's Euclid, the angles of incidence and reflection are equal---therefore they are equal.

MR. FINNY ought to know, that the angles of incidence and reflection are those that are made by the lines of incidence and reflection, with the reflecting surface; or with the perpendicular, indifferently. Sir Christopher Wren, and Mons. Huygens, who were the first that discovered the laws observed by perfectly elastic bodies. Dr. Keill who first demonstrated the theorem under consideration, and many other writers, consider the former as the angles of incidence and reflection: but suppose them confined to the latter (that we may allow MR. FINNY the greatest latitude possible) and that the equality of the former be assumed as a Datum, in that case, his demonstration will be reduced to an axiom; *If from equals you take away equals, the remainders will be equal*; one of the simplest truths in nature, and known to every rational being since the days of Adam.

But, in the name of curiosity, why does Mr. F. quote the great German Philosopher, Leibnitz, as an authority for the rectilinear motion of light; surely this was no discovery made, nor confirmed by Leibnitz. The rectilinear motion of light, in passing thro' the same medium, is deduced from the shadows which all opaque bodies cast, when placed in the light of the Sun, or any other luminous body; and from the impossibility of seeing it through a bended tube. But if Mr. Leibnitz should say, *a ray of light goes the shortest direction possible*; he must, indeed, be very ignorant of the nature of light, who would believe him; all that we should

* I strongly suspect that Mr. F. has made these quotations without attending sufficiently to the authors.

subscribe to in that case, is : *the natural motion of light is rectilineal*. The learned know, that a ray of light impelled from the Sun to us, is refracted on its entering the atmosphere, and becomes a curve; and for this reason, the Sun is seen in high latitudes for some days before he rises. Let me now examine how far Leibnitz has merited the appellation of a great philosopher: he charges Newton's philosophy with an impious tendency; his own system is an absurd combination of the Cartesian and Newtonian; for he retains the plenum and vortices of Des Cartes, and the gravity of Sir Isaac, though he does not resolve any of the principal difficulties to which the doctrine of the plenum and vortices is exposed, particularly the motion of comets in all directions. The exclusion of atoms, and all hard inflexible bodies, is required by his system: he asserts, that matter is not a substance but a substantiatum. The effects of different motives on the mind, he compares to weights placed in the scales of a ballance, and consequently introduces the system of absolute necessity.

The temporary reputation which he had acquired, arose from a supposition that prevailed for some time, that he was the original discoverer of the method of Fluxions: but it has been known for a long time past, that this discovery, which he gave the world as his own, was an absolute plagiarism from the manuscript letters of Sir Isaac Newton. Mr. Locke, and Mr. Molyneux considered him as a man of contracted abilities.

Mr. F. has misrepresented, and misquoted Bishop Berkely: the learned Prelate shews in his *new theory of vision*, (for, I believe he never gave the title of *Berkely's Philosophy* to any of his works) that there are two kinds of objects apprehended by sight; the one properly tangible, that is, to be perceived and measured by touch; and not immediately falling under the sense of seeing: the other properly and immediately visible; by mediation of which the former is apprehended: hence, it follows that a tangible diagram (in the Doctor's sense) is the external figure, which always continues of the same magnitude; and that *the representative of a tangible diagram*, is the internal figure, or picture, of the former, as painted on the Retina of the eye; and whose magnitude varies, as the external figure approximates to, or recedes from the eye. It is somewhat unaccountable how so great a genius as Mr. F. could fall into these little errors; that Mr. F. is a man of very deep learning I am ready to believe; and certain I am if he had sufficiently revolved the subject in his mind, he would have written on it with elegance and propriety.

Postscript. In *Part III*, which will soon be published, we will give the construction and use of the Astronomical and Galilean retracting Telescope; of the Newtonian, Gregorian and Cassagrain Reflectors, and many other curious Optical Glasses.

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